Z. Säugetierkunde **64** (1999) 1–11

ZEITSCHRIFT FÜR SÄUGETIERKUNDE
INTERNATIONAL JOURNAL OF MAMMALIAN BIOLOGY

Morphological and colour variation in the Pyrenean desman *Galemys pyrenaicus* (Geoffroy, 1811)

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Receipt of Ms. 10. 03. 1998
Acceptance of Ms. 18. 11. 1998

Abstract

This study presents information on biometry and colouring of *Galemys pyrenaicus.* The material studied covers the entire distribution area of this species on the Iberian Peninsula. Based on the data examined, no significant geographic differences were found as far as skull size was concerned. However, skull sizes and some of the body measurements taken from animals native to the Pyrenees and included in the subspecies *pyrenaicus*, are intermediate between subspecies from Galicia and the Iberian Mountains, and included in the subspecies *rufulus.* These data diminish some of the validity accorded to craniometric measures as one criterion to justify the existence of subspecies. Colour allows for a better differentiation although the chorological patterns do not coincide with those established by other authors. We suggest that *Galemys pyrenaicus* is distributed in totally or partially isolated populations, which could favour the process of morphological differentiation. This emphasises the importance of preserving every population area of this species.

Key words: *Galemys pyrenaicus*, taxonomy, morphology, colour

Introduction

Since the first description of this species by Geoffroy (1811) in the last century, and description by Graells (1897), sufficient differences in coloration have been seen between the typical form and the desmans from the central Iberian Peninsula in order to consider the latter as a new variety. Only in studies by six authors (Miller 1912; Cabrera 1914; Niethammer 1970; Palmeirin and Hoffmann 1983; Juckwer 1990) has there been any mention of the variability in form and size seen in the desman *Galemys pyrenaicus* in its distributional area.

Geoffroy (1811) described the dorsal fur as being dark brown ("brun marron") in colour. Years later Graells (1897) based his new variety, *Myogalea rufula*, noting that the yellow colour of the hairs on the back renders the animal to appear to have gold reflexes, while in the type specimen these reflexes appear silver. He also reported as a distinguishing trait, the bright yellow colour of the paws and nails of the desmans from the Central Mountains.

Miller (1912) described the coloration of *Galemys pyrenaicus rufulus* as not as dark as that of the subspecies of the Pyrenees. This author reports that the form *rufulus* appears to be clearly differentiated from *pyrenaicus* owing to its larger size and especially to the greater length and strength of the skull.

0044-3468/99/64/01 – 001 $ 12.00/0

Cabrera (1914) did not find any substantial differences in coloration between the two forms and he even claimed that the original description of *rufulus* was totally useless for recognising the animal in question. He did, however, maintain the existence of two subspecies attributing the bulk of the differentiation to the size; indicating, as discriminating parameters, the length of the rear foot and the condylobasal length.

Niethammer (1970) cautioned that although the form *rufulus* is larger in size, the measurements do overlap. He also pointed out that fur colour varies depending on wear.

Palmeirin and Hoffmann (1983) considered that the subspecies are distinct, although morphological differences between them are not great.

Lastly Juckwer (1990), through the examination of body weight and condylobasal length, attempted to reaffirm the idea that the subspecies *rufulus* is greater in size than the subspecies *pyrenaicus.*

The purpose of this study is to provide information on the biometry and coloration of the desman, analyse the geographic variation of this species on the Iberian Peninsula and discuss its present taxonomic status.

Material and methods

The material studied consisted of all together specimens from different collections (Tab. 1). In addition we used biometric data provided by Miller (1912), n = 6; Niethammer (1970), n = 18; Juckwer (1990), n = 20 (Tab. 1). It is important to note that material from the Central Mountains was not available. The presumable precariousness of the populations living in these mountains made it inadvisable to collect material there.

In order to evaluate the geographic variation of the size, the specimens were divided into 5 groups (Fig. 1).

Table 1. Origin and composition of the material. Sources: 1 – Museo Luis Iglesias, 2 – Estación Biológica de Doñana, 3 – Museo de Ciencias Naturales, (Alava), 4 – Collection from Pablo Aguirre, 5 – Facultad de Biología, Universidad de León, 6 – Museo Luis Iglesias (Santiago de Compostela), 7 – Niethammer (1970), 8 – Miller (1912), 9 – Juckwer (1990), 10 – own material

Population	Province	Location	U.T.M.	Skull	Fur	Source
Occidental 1	La Coruña:	–	–	–	1	1
	Lugo:	Trascastro-Incio	29TPH32	5	–	2
		Saa de Incio	29TPH32	8	–	2
		San Pedro de	29TPH32	5	–	2
		Incio	29TPH32	10	–	2
		San Román	29TPH54	1	–	6
		Cadramón	29TPJ10	1	–	6
		Barbeitos	29TPH67	1	–	6
		Río Ulla		1	1	1
	Pontevedra:	Río Riobó		1	1	1
		Vila de Cruces	29TNH63	–	1	1
	Orense:	Xunqueira de	29TPG07	1	–	6
		Sierra de	29TPG36	1	–	6
		Ramirás	29TNG77	1	–	6
		Riobó	29TPG26	1	–	6
	León:	Matarrosa del Sil	29TQH03	3	–	2
		Paramo del Sil	29TQH04	2	–	2
		Peranzanes	29TPH95	2	–	2
		Manzaneda	29TQG28	2	–	2
		Sierra Cabrera	29TPG97	1	–	2
		Montrondo	29TQH24	1	1	2

Table 1. Continued

Population	Province	Location	U. T. M.	Skull	Fur	Source
Occidental 2	Asturias:	Pola de Somiedo	29TQH27	4	–	2
		Arriondas	30TUP20	2	–	2
		Caleao	30TUN08	1	1	10
	Cantabria:	Turieno	30TUN67	4	–	2
		Rio Quiviesa	30TUN67	1	–	2
		Rio Hijar	30TUN96	1	–	2
		Reinosa	30TVN06	2	–	2
		Espinama	30TUN57	3	–	2
	León:	Besande	30TUN45	1	–	2
		Candemuela	29TQH46	6	7	10
		Riano	30TUN35	1	–	7
		Pajares	30TTN76	1	–	8
		San Emiliano	29TQH46	1	1	10
Pyrenees	Navarra:	Burguete	30TXN36	6	–	7
		Quinto Real	30TXN26	50	49	10
		Aoiz	30TXN34	1	1	10
		Orbara	30TXN45	1	1	10
		Oroz-Betelu	30TXN35	1	–	10
		Saigos	30TXN25	1	–	10
		Akerreta	30TXN15	1	–	10
		Lanz	30TXN16	2	–	10
		Huizi	30TWN87	2	–	10
		Oricain	30TXN14	1	–	10
		Riba	30TXN15	1	–	10
		Itoiz	30TXN34	1	–	10
		Osteriz	30TXN25	1	–	10
		Garzaron	30TWN96	2	–	10
		Guerendain	30TXN05	1	–	10
	Álava:			–	2	3
Iberian	Burgos:	Santo Domingo de	30TVM64	1	–	2
		Santo Domingo de	30TVM64	5	–	8
	La Rioja:	Sierra de Cameros	30TWM27	3	–	7
		Sierra de Cameros	30TWM27	20	–	9
		Ajamil	30TWM46	1	1	4
		Peroblasco	30TWM67	1	1	4
		Aguillar de Río	30TWM84	1	1	4
		Vadillos	30TWM47	1	1	4
		Valdepecillo	30TWM75	1	1	4
Central	Ávila:	Sierra de Gredos	30TTK95	8	–	7

The following measurements were studied: Body: HBL (head + body length), TL (tail length), HFL (hind foot length) W (body weight in grams); cranium: CBL (condyle-basal length), I^1–M^3 (I^1–M^3 length), BW (skull case width), IOW (interorbital width), ML (mandibular length), CH (coronoid height), BH (skull case height). The CBL was measured following Juckwer (1990). Since the points used by this author to define this parameter do not coincide with those used by Miller (1912) and Niethammer (1970) this study did not rely on the LCB measurements given by the latter authors.

The relative size was assessed according to Grulich (1967) for *Talpa*, taking into account tooth wear. Although all the teeth suffer from deterioration, it is more visible in the incisors, canines, and premolars. Animals with the cusps of teeth intact or only little evidence of wear were considered young. Animals showing abrasion down to the middle of the crowns were considered adults, and those that had a highly deteriorated set of teeth – in some cases the crown was completely lacking – were considered old adults. Where possible, characteristics of the reproductive system, such as size and degree of development were taken into account to supplement the age criteria.

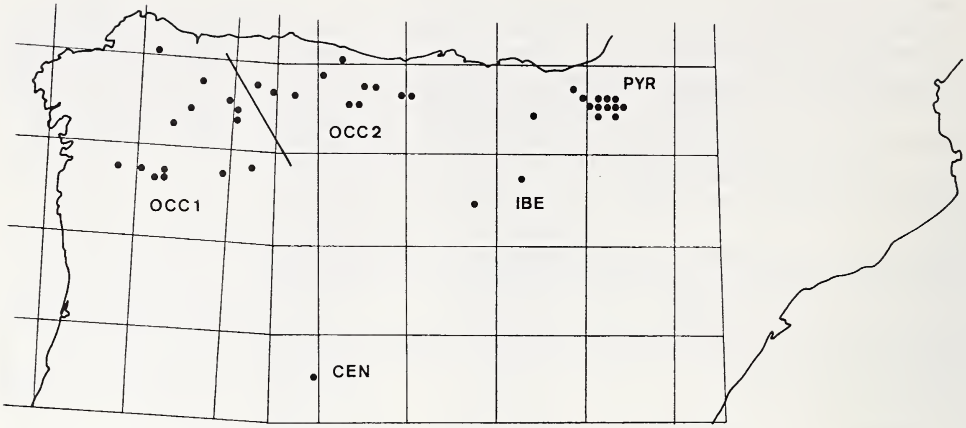

Fig. 1. Study area and different population groups. Occ1: animals from Galicia and the west of the province of León; Occ2: animals from Asturias, Cantabria, and the north of the province of León; Pyr: animals from Navarra; Ibe: animals from La Rioja and the south of the province of Burgos; Cen: animals from the province of Ávila

In order to evaluate the geographic variation of coloration, only those animals were considered showing new fur or fur grown after the moult. Thus, we counted 5 specimens from the Occidentall population, 9 from Occidental 2, 17 from the Pyrenees, and 5 from the Iberian Mountains.

The normality of the distribution of the variables was determined by the Kolmogorov-Smirnov test (Nie et al. 1975). The comparison between mean sampling pairs was carried out according to the method of Scheffé (Nie et al. 1975). The degree of differentiation between the different groups in terms of sex, age, and season of the year that the animal was caught was estimated based on the set of variables chosen through the multivariate analysis of variance (MANOVA) (Nie et al. 1975). The geographic variation of size was evaluated by a step-by-step discriminating factorial analysis choosing the variables which maximise the D^2 of Mahalanobis between the two closest groups (Nie et al. 1975).

Results

Size

Morphometric and craniometric data of the populations are given in table 2. An analysis of the total variability of the parameters considered resulted in no differences concerning size that may be attributed to sex (T^2 from Hotellings = 0.794; F = 1.192; $p > 0.05$), age (T^2 from Hotellings = 1.914; F = 1.355; $p > 0.05$), or season (T^2 from Hotellings = 3.058; F = 1.416; $p > 0.05$).

Individual comparisons between pairs of samples (Tab. 3) indicate that desmans from the Occidental 1 population have smaller skulls. This is the group that has the greatest number of contrasts with significant differences of several measures (18 out of 22 comparisons). As far as body measurements are concerned, the Iberian group has the lowest values. However, from the comparisons it is not possible to establish a clear pattern of geographic variation of these parameters.

A preliminary discriminating analysis was carried out based on five craniometric variables (CBL, I^1–M^3, BW, IOW, ML) and on the first four groups considered (OCC.1, OCC.2, PYR., IBER.). The discriminating function which explains a greater percentage of the variance (66.83%) selects four variables: $D = (-0.063) \times CBL + (1.091) \times I^1\text{–}M^3 + (-1.498) \times IOW + (2.189) \times ML - 54.384$. The standardised coefficients of this function

Table 2. Morphometric (in mm and grams) and craniometric (in mm) values of the populations studied

		n	$\overline{X}$	S	min.	max.
CBL	OCC1	50	33.8	1.22	29.4	35.5
	OCC2	15	34.8	0.60	33.8	36.0
	PYR	67	34.4	0.57	33.0	35.5
	IBE	26	34.9	0.57	34.1	36.2
	CEN	–	–	–	–	–
I^1–M^3	OCC1	50	16.6	0.66	14.8	17.8
	OCC2	15	17.1	0.29	16.6	17.8
	PYR	67	16.7	0.34	15.9	17.7
	IBE	26	17.0	0.24	16.3	17.3
	CEN	–	–	–	–	–
BW	OCC1	50	16.1	0.58	14.9	17.5
	OCC2	21	16.6	0.52	15.6	17.5
	PYR	67	16.4	0.34	15.7	17.2
	IBE	30	16.7	0.45	15.5	17.8
	CEN	–	–	–	–	–
IOW	OCC1	50	6.1	0.25	5.3	6.6
	OCC2	21	6.4	0.22	6.0	6.8
	PYR	67	6.4	0.21	6.0	7.0
	IBE	31	6.2	0.23	5.9	6.8
	CEN	–	–	–	–	–
BH	OCC1	50	10.8	0.50	9.2	12.0
	OCC2	15	11.1	0.45	10.5	11.8
	PYR	67	11.2	0.27	10.5	11.8
	IBE	6	11.5	0.15	11.2	11.6
	CEN	–	–	–	–	–
ML	OCC1	25	21.5	0.63	19.7	22.7
	OCC2	15	22.0	0.46	20.9	22.6
	PYR	66	21.7	0.38	20.7	22.6
	IBE	30	22.3	0.52	21.6	24.0
	CEN	–	–	–	–	–
CH	OCC1	25	10.4	0.31	10.0	11.0
	OCC2	14	10.8	0.45	9.9	11.5
	PYR	67	10.8	0.33	10.0	11.5
	IBE	5	10.8	0.21	10.5	11.0
	CEN	–	–	–	–	–
HBL	OCC1	6	122.8	13.70	110	145
	OCC2	19	125.6	5.38	112	135
	PYR	68	121.9	6.67	104	133
	IBE	29	116.1	6.68	106	129
	CEN	8	116.5	6.39	108	125
TL	OCC1	5	138.4	5.08	135	147
	OCC2	19	143.2	9.53	113	156
	PYR	68	139.7	6.54	123	154
	IBE	29	137.6	8.99	118	156
	CEN	8	148.1	5.94	140	155
HFL	OCC1	6	33.9	0.97	32.5	35.0
	OCC2	19	34.9	1.32	31.0	36.5
	PYR	68	35.4	1.07	31.0	37.5
	IBE	29	34.5	1.21	32.5	36.9
	CEN	8	33.9	0.88	32.5	35.0
W	OCC1	3	66.0	3.46	64	70
	OCC2	11	76.0	3.90	70	81
	PYR	66	68.6	7.38	48	83
	IBE	29	65.5	8.27	51	80
	CEN	8	68.4	7.73	60	79

Table 3. Individual comparisons between pairs of samples for each variable analysed according to the method of Scheffe. OCC1: Occidental 1 population; OCC2: Occidental 2 population; PYR: Pyrenean population; IBE: Iberian population; CEN: central population. The probability of error is noted when there are significant differences. * = No significant differences. – = Test was not carried out (sample size less than 5).

	OCC1–OCC2	OCC1–PYR	OCC1–IBE	OCC1–CEN	OCC2–PYR	OCC2–IBE	OCC2–CEN	PYR–IBE	PYR–CEN	IBE–CEN	Minor to highest size				
CBL	0.05	0.05	0.05	–	*	*	–	*	–	–	OCC1	PYR	OCC2	IBE	
I^1–M^3	0.05	*	0.05	–	0.05	*	–	*	–	–	OCC1	PYR	IBE	OCC2	
BW	0.05	0.05	0.05	–	*	*	–	*	–	–	OCC1	PYR	OCC2	IBE	
IOW	0.05	0.05	*	–	*	*	–	0.05	–	–	OCC1	IBE	OCC2	PYR	
BH	0.05	0.05	0.05	–	*	*	–	*	–	–	OCC1	OCC2	PYR	IBE	
ML	0.05	*	0.05	–	*	*	–	0.05	–	–	OCC1	PYR	OCC2	IBE	
CH	0.05	0.05	*	–	*	*	–	*	–	–	OCC1	PYR	IBE	OCC2	
HBL	*	*	*	*	*	0.05	0.05	0.05	*	*	IBE	CEN	PYR	OCC1	OCC2
TL	*	*	*	*	*	*	*	*	*	0.05	IBE	OCC1	PYR	OCC2	CEN
HFL	*	*	*	*	*	*	*	0.05	0.05	*	CEN	OCC1	IBE	OCC2	PYR
W	–	–	–	–	0.05	0.05	*	*	*	*	IBE	CEN	PYR	OCC2	

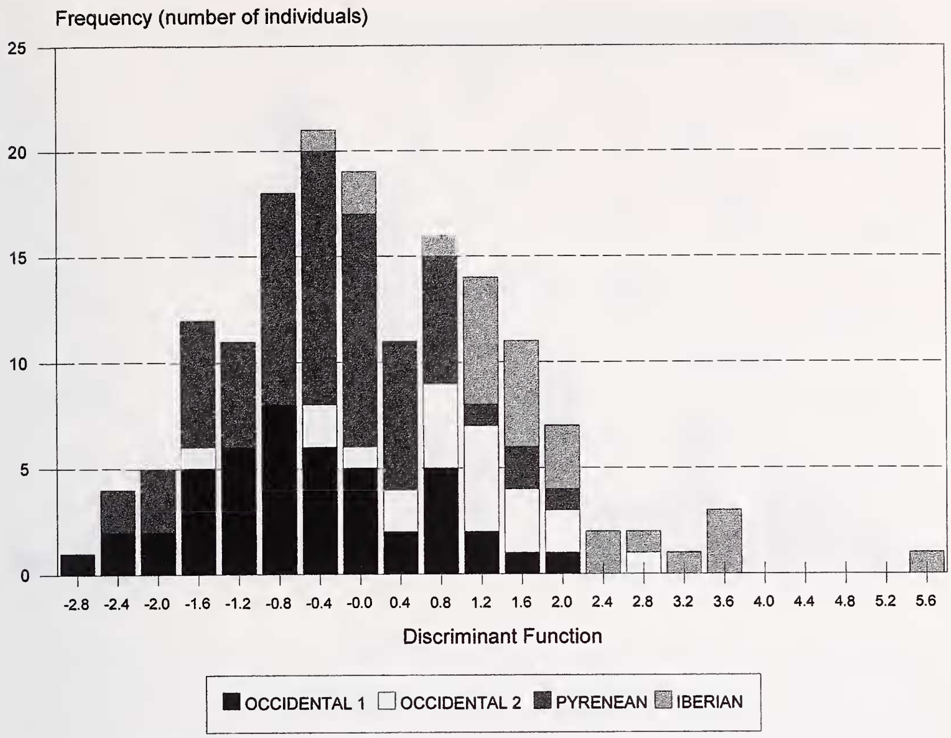

Fig. 2. Distribution of the sample analysed according to the discriminating function considering five craniometric sizes (CBL, I^1–M^3, BW, IOW, ML)

(ML = 0.86; I^1–M^3 = 0.46; IOW = –0.33; CBL = –0.04) and the correlation coefficients between the variables and the function (ML = 0.89; I^1–M^3 = 0.54; IOW = 0.01; CBL = 0.57) highlight I^1–M^3 and ML as the variables with the greatest discriminating power. Although their significance reaches a value which is high enough to warrant attention (Lambda de Wilks = 0.623, $p < 0.001$), it should be noted that only 61.6% of the sample (Fig. 2) is accurately classified. According to the data obtained, there is a wide overlap between the groups under comparison. The ordination of the centroid values of the groups situates the Occidental 1 (–0.61) and Pyrenean (–0.45) populations on the negative side of the function and the Occidental 2 (0.77) and Iberian (1.62) populations on the positive side. Since I^1–M^3 and ML have a positive correlation with the function, this ordination highlights the smaller skull size of the animals from Occidental 1 and Pyrenean populations.

A second discriminating analysis was carried out, adding the body parameters HFL, HBL, and TL to the variables used in the first analysis. In this case only the animals from the Occidental 2, Iberian, and Pyrenean populations presented complete information of the parameters under consideration. The discriminating function which explains a higher percentage of variance (89.6%) makes a selection of seven variables: D = (–0.81) × CBL + (–1.57) × I^1–M^3 + (2.07) × IOW + (–1.41) × ML + (0.91) × HFL + (0.04) × TL + (0.05) × HBL + 29.04. The standardized coefficients of this function (ML = –0.56; I^1–M^3 = –0.43; IOW = 0.45; CBL = –0.44; HFL = 0.78; TL = 0.23; HBL = 0.29) and the correlation coefficients among the variables as well as the function (ML = –0.41; I^1–M^3 = –0.33; IOW = 0.18; CBL = –0.25; HFL = 0.36; TL = 0.21; HBL = 0.30) point to I^1–M^3, ML, CBL, IOW, and HFL as the parameters with the greatest discriminating power.

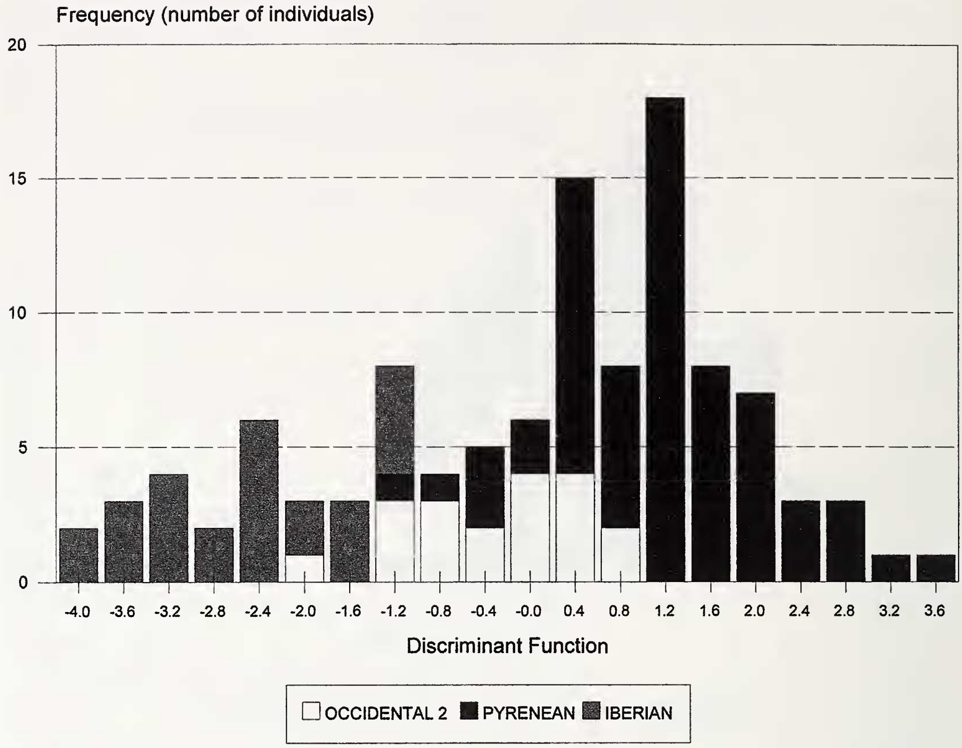

Fig. 3. Distribution of the sample analysed according to the discriminating function considering five craniometric sizes (CBL, I^1–M3, BW, IOW, ML) plus three body sizes (HFL, HBL, TL)

In this case the efficiency of the function obtained is relatively high since it provides an accurate classification percentage, 87.3% (Fig. 3). The ordination of the centroid values of the groups places the Iberian population on the negative side of the function (–2.82) and the Pyrenean population on the positive side (1.25), while the Occidental 2 population is intermediate in location (–0.44). Since the selected skull lengths correlate negatively with the function and IOW and HFL have a positive correlation, this ordination assigns a shorter and stronger skull and longer foot to the Pyrenean population as compared to the Iberian population.

Fur coloration

Based on an examination of all the pelts taken from the Quinto Real (Navarra), no differences in coloration were noted among the three relative age classes, if we compare animals caught during the same season. However, differences were seen upon comparing animals of the same age caught during different seasons. This is due to the wear the guard hairs are subject to (in the desman there are two types of guard hairs, the most common being the ones Poduschka and Richard (1985) call "Grannen"). After examining these hairs under the light microscope, the distal ends were seen to be intact and the coloration at first glance appears to be uniformly dark brown in young animals that have just grown a coat of fur or in adults that have recently moulted (animals caught between July and September). In contrast, in animals caught between January and March there are fine yellowish spots on the back. These spots are the distal ends of the "Grannen". With the light

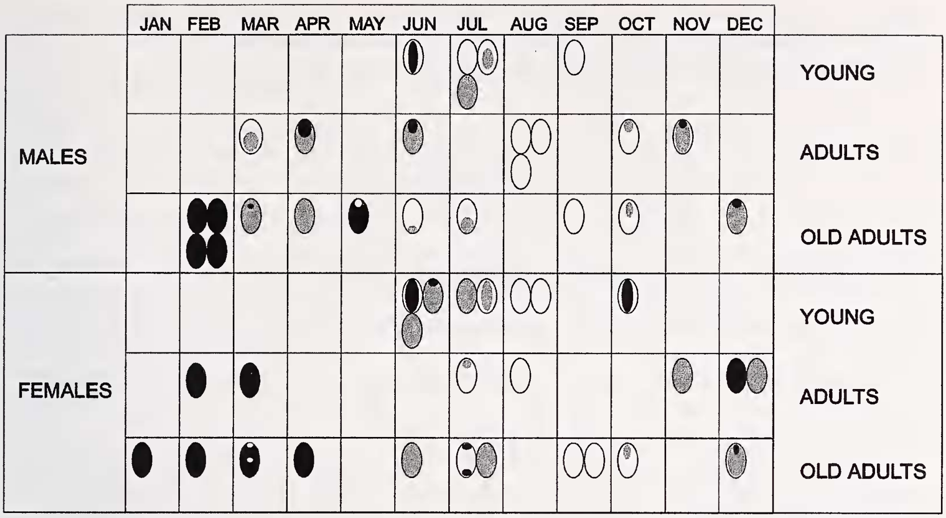

Fig. 4. Distribution of the area mottled in the dorsal fur. The darkest zones represent a greater yellowish spot density. The studied individuals appear distributed in function of their relative age and their month of capture

microscope it can be seen that these ends are split and appear dark and soiled. This worn fur has a yellowish tint at first glance, which corresponds to the spots seen in the old, worn fur. The notion that this variation in coloration is due to the deterioration of the fur was corroborated, when the group of pelts was arranged by months of capture and age (Fig. 4). The distribution of the dorsal spots and the temporal sequence observed would suggest that the moulting of the dorsal fur follows a regular pattern and is completed in August and September.

The coloration of the ventral part has a similar evolution. In June–August when the animal has new fur, the ventral part is white in colour; as the fur gets older it starts turning yellow (with gold spots). No differences were seen between the sexes in terms of fur coloration.

On comparing fur coloration between the established groups of animals, the colour of the ventral part did not show any substantial differences. It could be described as a shiny greyish white. The colour of the dorsal fur, however, differed among specimens of the different groups. The animals from the Pyrenean population have a dark brown colouring, which in some cases is almost black. The animals from the Iberian population have a similar dorsal colouring, although slightly lighter. The animals belonging to the Occidental 2 population have a reddish dorsal colouring, which is considerably lighter and they are the only specimens having yellow forepaws, feet, and nails. The latter fits the description that Graells (1897) gave of the subspecies *rufulus*. The animals from the Occidental 1 population have a light coloration similar to those of Occidental 2 with the exception of one specimen which is slightly darker. In specimens having dry fur it was not possible to detect differences in shade between the worn fur of the different groups studied.

Discussion

Based on the data analysed it is difficult to find structured patterns in relation to skull size. The craniometric values of the animals from the Pyrenees, described as *pyrenaicus*, are intermediate between the specimens from Galicia and the Iberian range, both described as *rufulus*, which would discredit the opinion of Miller (1912) and Cabrera (1914) who based the discrimination of the subspecies on size.

The fur coloration does, however, show geographic differences, which would contradict, in this case, Cabrera's (1914) opinion. The animals from the Pyrenees, Basque Country and the Iberian Range are dark brown (blackish) in colour, while the animals from the occidental area (León, Asturias, Galicia) belong to the light brown (reddish) type. The spots in the fur alluded to by Graells (1897) are due to the deterioration of the fur.

In its distribution area *Galemys pyrenaicus* presents a morphological variability that does not allow a clear differentiation to be made between the two subspecies described. It is only the coloration that fits a general geographic pattern, distinguishing the specimens from the Pyrenees and Iberian Range from the remainder, although within each of the two groups there is still a certain degree of heterogeneity. The morphometric and colouring observations obtained do not support the distributions of the two subspecies as described in the bibliography.

Thus, the distribution of the population variations would be more complicated than the simple description of the two known subspecies. The desman is a species linked to the high regions of the rivers (Castién and Gosálbez 1992). The dispersive characteristics of this species have not been examined to date, but dispersion is certain to be basically related to river courses. This would lead us to state that total or partial isolation between the populations of this species is a common occurrence. Moreover, if we add the territorial character of these animals and their low density (Stone 1987), it would be possible to consider that genetically related phenomena occur. The existence of these phenomena may explain the presence of local variations throughout the distribution area of the species. An in-depth genetic study would make it possible to establish the taxonomic importance of these variations in the future.

Acknowledgements

The authors would like to thank Pablo Agirre-Mendi, Gorka Belamendia (Museo de Ciencias Naturales de Álava), Estación Biológica de Doñana (Sevilla), Museo Luis Iglesias (Santiago de Compostela) and Dr. Francisco J. Purroy (Facultad de Biología de León) for kindly providing the material studied. The authors are also grateful to I. Leránoz for her generous help in the collection of our own material. This study was partially funded by the Secció de Ciencies Biologiques de l'Institut d'Estudis Catalans (Barcelona).

Zusammenfassung

Morphologische und Färbungsvariationen beim Pyrenäen-Desman Galemys pyrenaicus (Geoffroy, 1811)

Die Arbeit enthält Angaben über Biometrie und Färbung des Pyrenäen-Desman *Galemys pyrenaicus*. Die Autoren untersuchen die geographische Variation der Größe und Färbung dieser Art innerhalb der Iberischen Halbinsel und kommentieren den derzeitigen taxonomischen Wissensstand. Das untersuchte Material bezieht sich auf alle Regionen der Iberischen Halbinsel, in denen diese Art vorkommt. Die Ergebnisse dieser Analyse zeigten in bezug äuf die Schädelgröße keine bedeutenden geographischen Unterschiede. Sowohl die Schädelgröße als auch einige andere Körpermaße der in den Pyrenäen lebenden Unterart *pyrenaicus* liegen zwischen den Maßen der in Galicien und dem Iberischen Gebirge lebenden Unterart *rufulus*. Dieses Ergebnis stellt die Heranziehung der Schädelgröße als Maßstab für die Unterscheidung von Unterarten in Zweifel. Eindeutigere Unterscheidungsfaktoren bestehen bezüglich der Farbe, allerdings stimmen hierbei die chorologischen Modelle nicht mit

denjenigen anderer Autoren überein. Die vorliegende Studie legt nahe, daß die einzelnen Populationen von *Galemys pyrenaicus* zum Teil oder gänzlich isoliert sind, wodurch eine morphologische Unterscheidung begünstig sein kann. Diese Tatsache hebt die Notwendigkeit der Erhaltung jedes einzelnen dieser Siedlungskerne hervor.

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